

PEGGY GREB (K10856-1)

Helping Plants Defend Themselves



Roots of potatoes treated with a SAR activator are examined for disease symptoms by soil microbiologist Harold Collins (left) and geneticist Roy Navarre.



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Peter Landolt, head of ARS's Fruit and Vegetable Insect Research Unit, Wapato, Washington, applies a plant hormone precursor to a potato plant to induce chemical defenses against insects.

People aren't the only ones to benefit from salicylic acid, the active ingredient in aspirin. Research has shown that spraying this naturally occurring compound onto some plants triggers natural defenses that keep harmful fungi, bacteria, and viruses at bay.

Plants have always had some means to defend themselves; it's just that some don't recognize their microbial attackers in time. Spraying salicylic acid or certain other compounds snaps them to attention and puts their defenses on high-alert against future attacks.

Plant scientists first encountered the phenomenon, called systemic acquired resistance (SAR), in the 1930s. Plants make salicylic acid, particularly after encountering a pathogen, and use it as a key regulator of SAR and expression of defense genes. But only recently have companies begun marketing salicylic acid and other similar compounds as a way to activate SAR in crops—tomato, spinach, lettuce, and tobacco among them.

Little is known about the benefits of such products on potatoes, but a team of Agricultural Research Service (ARS) scientists in Prosser, Washington, has begun studies to find out.

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ARS scientists are experimenting with spraying natural compounds on potato plants to induce plant resistance to fungal and insect pests like these cabbage looper larvae, shown here on potato leaves.



Technician David Mayo prepares to extract RNA from samples of potato leaves treated with a SAR activator.

“A major objective of our research is to understand how SAR functions in potatoes so that we can ultimately use it in the field for disease control,” says Roy Navarre, a molecular biologist and team leader at ARS’s Vegetable and Forage Crops Research Unit in Prosser. “Systemic acquired resistance is a basic mechanism by which plants protect themselves, so we want to take advantage of that as much as possible.”

Navarre’s chief collaborators are ARS scientists Pete Thomas, Chuck Brown, Nik Grunwald, Hal Collins, and Peter Landolt. Pradeep Kachroo, another collaborator, is with the University of Kentucky-Lexington. The Washington State Potato Commission partly funded the project.

If spraying salicylic acid or other compounds on potatoes to activate SAR works, it should help ease reliance on synthetic pesticides to battle

various disease organisms and insects that can diminish the tuber yields and quality of potatoes, a crop that generates nearly \$3 billion annually in U.S. farm sales and is a staple food for 1.5 billion people worldwide.

Rousing Dormant Defenses

Particularly intriguing is the prospect of activating SAR as a fast, cost-effective means of protecting cultivars that are agronomically profitable but prone to disease.

“Plants may have all the tools they need to be resistant to certain pathogens. It’s just that sometimes they become infected because they don’t turn on their defenses rapidly enough,” says Navarre. “If we can get SAR to flip this switch, we could extend the life and usefulness of susceptible but otherwise good cultivars.”

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A potato infected with root-knot nematode (left) and a healthy potato.

In nature, SAR can begin when a single fungal spore lands on a leaf and germinates there. Plants can have what’s called a hypersensitive response. It commands cells at the site of infection to kill themselves, which helps cordon off the microbial invader. About a week later, a signal travels from the site of infection on the leaf to the rest of the plant, activating a battery of defense mechanisms. Plants then synthesize antimicrobial substances, including the protein chitinase, which degrades the cell walls of fungi, and enzymes called nucleases, which break apart the ribonucleic acid of viruses.

Despite extensive research on SAR in model plant systems like *Arabidopsis* and tobacco, Navarre says much has still to be learned about the defenses that signal compounds like salicylic acid to activate in potatoes.

In earlier studies, for example, he and co-investigators showed that the leaves and roots of potato plants naturally contain 100 times more salicylic acid than many other crops. Perhaps as a result, some of the defense genes involved in SAR are usually active to some degree—even if no infection has occurred.

Pest-Proofing Potatoes

The pathogens the researchers hope to stymie by activating SAR or similar defenses include fungi that cause the diseases late blight, white mold, and early dying complex, as well as two nonmicrobial pests. One pest is the green peach aphid, a soft-bodied, sap-sucking insect that spreads 10 different potato viruses. The other is the Columbia root-knot nematode. In the Pacific Northwest, where much of the U.S. potato crop is grown, farmers often spend \$250 an acre chemically fumigating their fields to get rid of the nematode before planting time. But one such fumigant, methyl bromide, is scheduled for complete phaseout by 2005 because of environmental concerns.

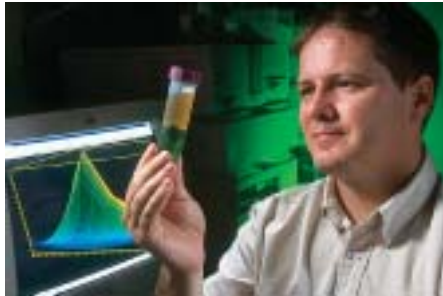
Earlier this year, Navarre's team began greenhouse experiments to monitor the effectiveness of salicylic acid and other activators in helping potato plants resist viruses, including potato virus Y.

"Potato viruses are the first pathogens we chose to work on because they're such a threat to the potato crop," says Navarre. "Furthermore, there aren't many economically feasible products that directly inhibit plant viruses, whereas SAR can be effective." But the activators the researchers are using don't act directly on the pathogens. Instead, their role is to stimulate plants' defense responses to attack.

For this study, the researchers first grow miniature potato plants from tissue culture. This ensures that the plantlets used in the study are free of pathogens that can trigger SAR activity before it's desired. The scientists then spray two groups of about 50 plantlets with the activators. A third group is left alone as a control. After that, they inoculate the plants with the virus, later checking them for disease symptoms, such as a yellowing of the leaf. They also check for the virus in tissue specimens taken from the plants, using ELISA (enzyme-linked immunosorbent assay) and PCR (polymerase chain reaction) tests.

Though the studies are still ongoing,

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Roy Navarre extracts salicylic acid from potato leaves and measures it with high-performance liquid chromatography.

"preliminary results are encouraging that SAR can be an effective potato defense," Navarre reports. Similar studies are planned later this year for other pathogens and the Columbia root-knot nematode.

Meanwhile, at ARS's Fruit and Vegetable Insect Research Unit in Wapato, Washington, research leader Peter Landolt is activating the potato plants with plant hormones to identify specific defense chemicals that stymie feeding by aphids and leaf-eating caterpillars such as the alfalfa looper. "We're trying to

figure out which of these chemicals the potato plant strengthens as a way to defend itself against attack by these insects," says Landolt.

Another research component involves measuring the degree to which SAR is expressed in treated plants, as well as in the plants' leaves, stems, roots, and tubers. The researchers are also spraying the plants with different application rates to find the best doses to use.

"It's possible one activator may be more effective in leaves and a different one more effective in the roots," Navarre explains. "So, if one is looking for resistance to a root pathogen, it's important to be using the compound and dosage that work best in roots."

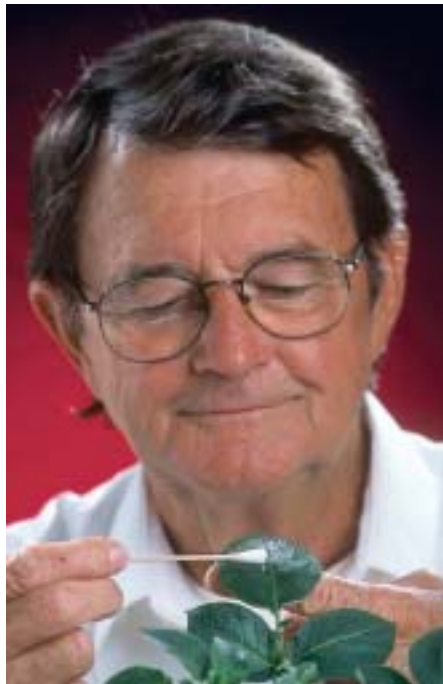
On yet another front, his team is monitoring how long it takes for SAR to kick in once the plants have been sprayed and how long it is effective. In a crop field, such information would "influence how often plants need to be treated," Navarre says. Studies in tobacco and other crops show that SAR can last for weeks to months. What's more, the plant during this period can resist pathogens other than the one that originally triggered the response.

Another interest is to identify and clone plant defense genes that are involved in boosting the effect of salicylic acid. Such genes could then be used by potato breeders to make new potato cultivars that can better resist diseases. Until then, "The better we're able to understand SAR, the better we'll be able to use it," says Navarre.—By **Jan Suszkiw**, ARS.

This research is part of Plant Molecular and Biological Processes, an ARS National Program (#302) described on the World Wide Web at www.nps.ars.usda.gov.

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A potato leaf previously treated with a SAR activator is inoculated with potato virus Y by virologist Pete Thomas.